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STAFFORDSHIRE COUNTY COUNCIL.

SEWAGE DISPOSAL AT HANLEY.

REPORT

By County Medical Officer of Health

ON

EXPERIMENTAL DISPOSAL PLANT.

Being an Extract from his Monthly Report presented to the Sanitary Committee, July 2nd, 1904.

STAFFORDSHIRE COUNTY COUNCIL.

EXTRACT FROM THE MONTHLY REPORT

OF THE

COUNTY MEDICAL OFFICER OF HEALTH,

Presented to the Sanitary Committee, July 2nd, 1904.

Sewage Disposal at Hanley.

Report upon Experimental Disposal Plant.

As the Committee are aware, about two years ago, in accordance with an undertaking on the part of the Hanley Corporation, works were constructed for treating one-sixth the dry weather flow of the sewage of Hanley on biological lines, the object being to determine, by experiment on a large scale, whether septic tank treatment followed by single filtration would yield satisfactory results with the sewage in question, and whether the process, if found to be efficient, could be conducted on the site of the present outfall works, which is somewhat near to a populous part of the Borough.

The plant was designed by Messrs. Willcox & Raikes, Engineers, Birmingham, in conference with myself, and in planning the filters, &c., regard was paid to future extension of the works on similar lines should the experiment prove successful.

As the plant has now been practically in constant operation for about eighteen months—during which time periodic surprise visits of inspection at short intervals have been made by the County River Inspector and myself, when samples, both of the sewage treated and the effluents, were collected for analysis—I think the time has arrived when a pretty confident opinion may be expressed regarding the wisdom of extending the works on the same lines.

Before commenting upon the results of my analyses of the samples collected, it will be convenient to give a short description of the plant, referring, at the same time, to the considerations which influenced us in coming to a conclusion as to what arrangement would be likely to yield the most useful information for the guidance of the Corporation when the time came for the consideration of the complete scheme for dealing with the whole of the sewage of the Borough.

For many years past, and up to the present time, the method of disposal has been by chemical precipitation, followed by land treatment. The land available, however, is of a clayey nature, most unsuitable for the purpose, and the area is quite inadequate. It was perfectly evident, therefore, that, if the present outfall was to be retained, all idea of land treatment, even as a supplement to other methods, must be discarded.

We were aware, before the experiment was started, that septic tank treatment, followed by double filtration, would produce a satisfactory effluent, and we had a pretty firm conviction that, with a highly efficient method of distribution of the tank effluent on the filter, one filtration, through a depth of filter of about 4ft. 6in., would answer the purpose. We also knew that broken saggars, a waste material which is plentiful in the pottery towns of North Staffordshire, formed a good filtering medium, being very hard and non-friable, but we had not quite determined the size of particles best suited for such filters.

The question of efficient distribution was not an easy one, there being, at the time the design of the works was under consideration, no mechanism available which was completely under control as regards volume delivered per yard of filter or duration of rest periods. Various types of automatic revolving distributors were then on the market, but none of these quite fulfilled the above conditions, and as we were anxious to arrive at a conclusion as to the capability of the plant under ideal conditions as regards distribution, efforts were made to obtain some appliance which would be under

complete control and allow of adjustment for experimental purposes as regards the quantity delivered and the intervals of delivery.

The method of distribution by fine sprays, even had such complied with the high standard desired, was out of the question, because of the nuisance which would undoubtedly have been experienced by the adjoining residents from the fine spraying of a septic effluent over a large area.

Having talked the matter over with Mr. Scott-Moncrieff, who has done so much excellent work in advancing both the science and technique of sewage disposal, he designed an apparatus which was ultimately fixed, and which has been at work in distributing the sewage on a circular filter throughout the time covered by the experiment.

Later on, Mr. Willcox designed a mechanical distributor, which was fixed in connection with a rectangular filter, and that apparatus also has been at work throughout the experiment.

I do not propose to comment upon the comparative merits of the two apparatus from a mechanical point of view, that being an engineering question, nor am I in a position to compare them from the point of view of capital cost and working expenses, but, from observations made throughout the experimental working of the plant, I can state that both complied with the stringent conditions as regards efficiency laid down in the first instance, and—I believe for the first time in the history of sewage disposal by artificial filtration—the distribution of the sewage was under complete control as regards the vital requirements of the biological process of purification.*

The total area of the experimental filters amounts to half an acre, consisting of a circular quarter-acre bed fed by the Scott-Moncrieff Distributor, and a rectangular quarter-

* As a matter of fact, owing to delay in the construction of the works at Hanley, a Scott-Moncrieff Distributor was in actual operation in connection with an experimental filter at the Birmingham, Tame, and Rea Joint Boards' Disposal Works a month or two before the apparatus was in use at Hanley.

acre bed fed by the Distributor designed by Mr. Willcox. The total depth of the filtering material in both cases is 4ft. 6in.

In order to determine what sized filter particles gave the best results, the filters were divided into sections differing as regards size of particles, and the effluent pipes were so arranged as to allow of distinct samples from each section being collected for analysis. The circular filter was thus divided into four, and the rectangular into two sections, the size of particles from below upwards being as follows:—

CIRCULAR FILTER.

Section I.—6″=2½″ to 1½″; 3″=1½″ to ½″; 3′ 9″=$\frac{3}{16}$″ to ⅛″ particles.

Section II.—6″=2½″ to 1½″; 3″=1½″ to ½″; 3′ 9″=½″ to ⅛″ particles.

Section III.—9″=2½″ to 1½″; 3′ 9″=½″ to ¼″ particles.

Section IV.—9″=2½″ to 1½″; 3′ 9″=1½″ to ½″ particles.

RECTANGULAR FILTER.

Section I.—1′=1½″ to ½″; 3′ 6″=$\frac{3}{16}$″ to ⅛″ particles.

,, II.—1′=1½″ to ½″; 3′ 6″=½″ to ⅛″ particles.

It will be noticed that Sections I. and II., in both cases, corresponded as regards size of particles in the body of the filter. The object of this was to allow of a legitimate comparison being made between the results of two filters worked under identical conditions, and differing only in the mechanism for distributing the sewage.

The filters, as already stated, were fed with a septic tank effluent, provision for which was made by adapting an existing tank so as to provide for twenty-four hours' storage of the sewage to be dealt with by the filters. It may be well to point out, however, that the routine working of the works generally interfered somewhat with the regularity with which the detritus tank was emptied, with the result that a larger proportion of the mineral suspended solids in the sewage passed into the septic tank than otherwise would have been the case, thus curtailing its effective capacity more

rapidly than is usual. The effect of this, no doubt, was, that the septic tank effluent was not the outcome of twenty-four hours' septic action throughout the whole period of the experiment, and, at times, probably an increase in the suspended solids passing from the septic tank to the filters resulted from this unavoidable shortening of the septic period.

The filters have now been in use for about eighteen months, the rectangular one, which was completed first, being started on December 6th, 1902, and the circular one on January 7th, 1903. Now and again it became necessary to discontinue their use for a few days at a time, owing either to the need for trifling repairs of machinery, or because of essential alterations in the general pumping plant, thus causing a temporary interruption in the delivery of sewage to the filters. On the whole, however, it may be said that during the time covered by the collection of the samples on which the conclusions in this report are based (a period of about fourteen months), the filters may practically be said to have been in constant use both day and night.

As regards the rate of flow, in the case of the circular filter, a constant and regular flow of 200 gallons per superficial yard was maintained. In the case of the rectangular filter, however, owing to a defect in the distributor, which I understand could easily be avoided in reproducing the apparatus, the delivery did not always amount to 200 gallons per yard, but varied from 130 to 200 gallons, the mean being 162 gallons.

A rate of flow of 200 gallons per yard per 24 hours was decided upon, because experience had shown in the case of other works that such a rate could not be exceeded without greatly reducing the degree of purification obtained, and this rate was maintained throughout (in the case of the circular filter) to allow of a sufficient number of records, extending over a sufficient period, being obtained to warrant a reliable conclusion being arrived at.

The rate of travel of the distributors was so adjusted that each yard of filter received its quantum of sewage at

seven minutes' intervals—the time recommended by Mr. Scott-Moncrieff as the outcome of his experience in the working of biological filters designed by him some years ago.

In future it might be well to test the power of the filters of dealing with an increased volume per 24 hours, and the distributors might be worked at different rates of travel, as it does not follow that a rate of 200 gallons per yard may not be exceeded with impunity in the case of filters worked under such perfect conditions as regards distribution, neither is it certain that the most effective inter-delivery period is seven minutes.

It would also be interesting and instructive to ascertain whether artificial ventilation of the filters, by means of an extracting fan placed in the effluent channel, would increase their efficiency to an extent which would warrant the adoption of such a means of assisting the nitrifying process. I understand that this experiment, in the case of the circular filter at any rate, might readily be tried.

So much for the plant and its working, the quality of the work done has now to be considered.

Attached to this report are tables giving the results of my analyses of the sewage and effluents.

As regards the quality of the sewage, the analytical records indicate that it is an ordinary domestic sewage not of a very strong character, the dilution being accounted for by the discharge into the sewers of a considerable volume of mine drainage water, as well as a certain amount of stream water from a small tributary stream, which—having received some sewage from Hanley and the adjoining Borough of Burslem—communicates with the outfall sewers.

In the following table the Means of the various analytical records set forth, in detail, in the tables at the end of this Report are shown, and from these it is possible to judge of the quality of the work done by the two filters and by the different sections of each :—

Analyses of Sewage and Effluents.
Mean Results in Parts per 100,000.

Sample.	Size of Particles in Body of Filter.	No. of Samples.	Parts per 100,000. Solids. In Solution.	Solids. In Suspension.	Solids. Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.
Sewage ...	...	8	125·4	62·9	188·3	8·9	2·109	0·765	3·854	0·00
Septic Tank	...	7	105·3	4·4	109·7	8·7	1·820	0·270	1·725	0·00
Rectangular. Sec. I.	3/16″ to 1/8″	14	112·0	0·4	112·4	8·5	0·081	0·029	0·273	1·75
Rectangular. „ II.	1/2″ „ 1/8″	14	111·9	0·3	112·2	8·3	0·098	0·032	0·278	1·73
Circular. „ I.	3/16″ „ 1/8″	13	112·1	0·2	112·3	8·4	0·096	0·025	0·242	1·66
Circular. „ II.	1/2″ „ 1/8″	13	112·9	1·4	114·3	8·3	0·036	0·029	0·259	1·53
Circular. „ III.	1/2″ „ 1/4″	13	112·8	0·7	113·5	8·4	0·037	0·030	0·252	1·62
Circular. „ IV.	1½″ „ 1/2″	13	113·1	1·7	114·8	8·3	0·119	0·046	0·327	1·62

In view of previous reports in which the matter has been fully explained, it is unnecessary to go into detail as to the significance of the various figures; I would remind the Committee, however, that the important figures to consider in judging of the degree of purification effected are those showing the reduction of oxygen absorbed and organic ammonia in the effluents compared with the sewage, as well as those showing the extent to which the organic nitrogen of the sewage has undergone oxidation, as indicated by the amount of nitric nitrogen in the effluents.

In compiling the above table of Means, I have omitted the first two records because some time is required for new filters to ripen or become active, especially when they start work in the cold winter months. I have also omitted the last records, because it happened that the rectangular filter had been at rest for repairs to the machinery for ten days, and the circular for 36 days previous to the collection of these samples, and one naturally would expect the results to be exceptionally good after such periods of rest, an expectation

which is very strikingly exemplified by the very high nitric nitrogen figures in the case of the circular filter effluents.

Shortly, the conclusion to be drawn from the figures is that in every case the degree of purification which has been effected is excellent. The good quality of the work done exceeds that of any plant of which I have had experience, neither do I know of any published records from similar works which will approach those of Hanley as regards the degree of purification effected.

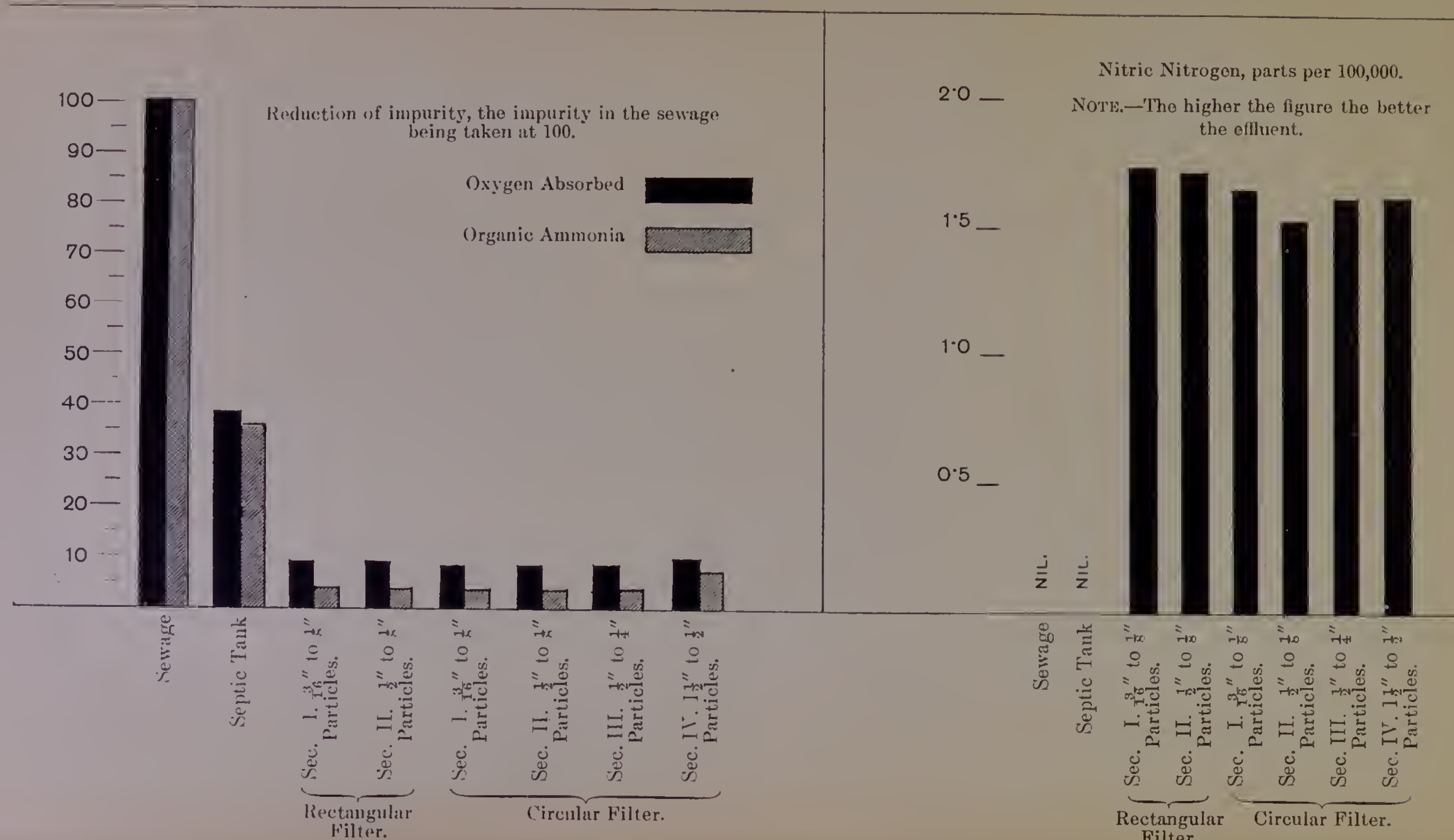
From the above table of mean results, I have prepared the attached diagram which shows very clearly the percentage purification effected by the various sections of the filters, based upon the percentage reduction in the organic ammonia and oxygen absorbed figures and the actual degree of nitrification.

It will be seen that treatment in the "septic" tank effected a purification of 64% and 62% in the organic ammonia and oxygen absorbed figures respectively, while as regards the filter effluents these percentages varied from 94% and 91% in the case of the large grain section of the circular filter to 97% and 94% in the case of the finest grain section, the last-named figures being practically the same in the corresponding section of both filters.

As regards the degree of nitrification effected, the results are practically the same in the case of all sections of both filters.

With reference to the routine working of the filters, I may mention that, with the exception of a temporary water-logging of the large-grain section of the circular filter (1½in. to ½in. particles), an occurrence which was corrected by a short period of rest, no trouble was experienced. That this occurrence should have happened in the case of the large grain section only, confirms the accuracy of the opinion I formed years ago, namely, that it is desirable to reduce the size of particles in such filters to an extent which is compatible with thorough aeration.

Diagram showing Degree of Putrification, as estimated by the reduction in Oxygen Absorbed and Organic Ammonia, and the amount of Nitric Nitrogen in the Effluents.



In this connection, however, the question of cost has to be considered. The crushing of the filtering material into very fine particles adds to the cost of construction, and, bearing this in mind, I have come to the conclusion, in view of the comparative results and having regard to efficiency and economy, that the Corporation of Hanley would be wise to make use of particles of the same size as those forming the body of Section III. of the circular filter, namely, ½in. to ¼in. With this grade of material, however, it would be wise to protect the filter by forming the top layer, to the depth of about 9 to 12 inches, of ½in. particles.

In conclusion, I may state that the working of the preliminary plant has exceeded my highest expectations, and I am of opinion that the Hanley Corporation may with confidence proceed on similar lines in laying down a plant of sufficient capacity to deal with the whole of the sewage of the Borough.

GEO. REID,

Stafford, County Medical Officer of Health.

June 29th, 1904.

SEWAGE.

Date.		Parts per 100,000.								Column necessary to obscure test lines (inches).
		Solids.								
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.	
1903. 19 May	1903. 21 May	118·5	59·0	177·5	9·0	1·176	0·286	3·872	Nil.	0·75
16 June	18 June	167·4	71·0	238·4	8·0	2·188	0·808	5·468	Nil.	0·75
15 July	17 July	132·3	55·2	187·5	10·8	2·320	0·960	2·668	Nil.	0·75
4 Aug.	6 Aug.	103·7	31·5	135·2	9·2	2·310	0·796	2·934	Nil.	1·0
25 Nov.	3 Dec.	127·2	77·9	205·1	7·4	2·180	0·492	2·275	Nil.	1·0
17 Dec.	17 „	90·4	86·6	177·0	7·6	1·880	0·916	5·667	0·25	0·5
1904. 19 Jan.	1904. 23 Jan.	126·3	64·3	190·6	9·6	2·324	0·664	3·113	Nil.	0·75
16 Feb.	19 Feb.	137·3	58·3	195·6	9·6	2·494	1·200	4·840	Nil.	0·75
	Mean...	125·4	62·9	188·3	8·9	2·109	0·765	3·854	0·03	

SEPTIC TANK.

Date.		Parts per 100,000.								Column necessary to obscure test lines (inches).
		Solids.								
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.	
1902. 19 Dec.	1902. 20 Dec.	89·2	4·4	93·6	9·0	2·200	0.360	2·334	Nil.	1·0
1903. 8 Jan.	1903. 13 Jan.	91·3	3·7	95·0	7·8	1·386	0·274	1·534	0·66	1·5
14 „	19 „	107·8	3·2	111·0	9·4	1·862	0·308	1·834	Nil.	1·5
10 Feb.	18 Feb.	100·8	3·7	104·5	9·6	2·040	0·312	2·397	Nil.	1·5
1 April	8 April	101·1	3·3	104·4	7·8	1·514	0·156	1·240	Nil.	3·0
28 „	30 „	116·2	5·2	121·4	9·6	2·346	0·274	1·767	Nil.	2·5
1904. 16 Feb.	1904. 19 Feb.	130·4	7·6	138·0	7·8	1·393	0·209	0·968	Nil.	2·25
	Mean...	105·3	4·4	109·7	8·7	1·820	0·270	1·725	0·09	

RECTANGULAR FILTER.—SECTION 1.—$\frac{3}{16}''$ TO $\frac{1}{8}''$ PARTICLES.

Date.		Parts per 100,000.									Column necessary to obscure test lines (inches).
		Solids.									
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.		
1902. *19 Dec.	1902. 20 Dec.	92·1	0·0	92·1	8·8	1·350	0·043	0·576	0·28		13·5
1903. *8 Jan.	1903. 13 Jan.	87·0	1·0	88·0	7·8	1·039	0·075	0·508	0·60		11·0
11 Jan.	19 Jan.	102·5	0·0	102·5	9·0	0·168	0·043	0·110	1·66		16·0
10 Feb.	18 Feb.	107·8	0·0	107·8	8·8	0·072	0·052	0·464	2·50		Over 2ft
27 „	3 Mar.	97·3	0·0	97·3	9·0	0·022	0·041	0·320	2·50		Over 2ft
12 Mar.	16 „	102·2	0·0	102·2	9·0	0·009	0·022	0·256	1·43		Over 2ft
1 April	3 April	106·0	0·0	106·0	8·4	0·039	0·025	0·256	1·54		Over 2ft
28 „	30 „	122·5	0·0	122·5	10·0	0·226	0·046	0·440	2·00		Over 2ft
19 May	21 May	102·2	0·0	102·2	8·4	0·038	0·028	0·284	1·58		Over 2ft
15 July	17 July	106·5	0·0	106·5	8·6	0·019	0·026	0·224	1·58		Over 2ft
4 Aug.	6 Aug.	94·0	6·7	100·7	9·2	0·080	0·027	0·256	1·67		Over 2ft
5 Nov.	9 Nov.	122·1	0·0	122·1	8·0	0·061	0·024	0·176	1·33		Over 2ft
25 „	3 Dec.	131·7	0·0	131·7	7·6	0·005	0·017	0·184	1·47		Over 2ft
17 Dec.	17 „	128·2	0·0	128·2	7·3	0·156	0·025	0·200	1·67		Over 2ft
1904. 19 Jan.	1904. 23 Jan.	113·5	0·0	113·5	8·0	0·010	0·019	0·144	1·92		Over 2ft
16 Feb.	19 Feb.	132·4	0·0	132·4	8·4	0·240	0·023	0·184	1·72		Over 2ft
*†7 Apr.	10 Apr.	114·7	0·0	114·7	7·4	0·003	0·016	0·240	1·33		Over 2ft
	Mean...	112·0	0·4	112·4	8·5	0·081	0·029	0·273	1·75		

* Not included in estimating the Mean.

† After 10 days' rest for repairs of machinery.

RECTANGULAR FILTER.—SECTION II.—½″ TO ⅛″ PARTICLES.

Date.		Parts per 100,000.								Column necessary to obscure test lines (inches).
		Solids.								
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.	
1902. *19 Dec.	1902. 20 Dec.	94·5	0·0	94·5	8·8	1·492	0·070	0·640	0·16	10
1903. *8 Jan.	1903. 13 Jan.	87·8	1·3	89·1	7·8	1·111	0·074	0·588	0·51	10
14 Jan.	19 Jan.	103·5	0·0	103·5	8·8	0·350	0·045	0·360	1·66	16
10 Feb.	18 Feb.	106·6	1·3	107·9	8·8	0·151	0·055	0·504	2·50	Over 2ft
27 „	3 Mar.	102·2	0·0	102·2	8·4	0·053	0·058	0·360	2·86	19
12 Mar.	16 „	99·7	0·0	99·7	8·8	0·012	0·028	0·280	1·54	Over 2ft
1 April	3 April	103·2	0·0	103·2	8·2	0·024	0·034	0·256	1·43	Over 2ft
28 „	30 „	125·3	0·3	125·6	9·4	0·244	0·050	0·428	1·75	Over 2ft
19 May	21 May	102·4	0·0	102·4	8·4	0·012	0·030	0·284	1·58	Over 2ft
15 July	17 July	104·7	0·0	104·7	8·8	0·013	0·026	0·256	1·55	Over 2ft
4 Aug.	6 Aug.	93·2	2·2	95·4	9·2	0·107	0·027	0·256	1·61	Over 2ft
5 Nov.	9 Nov.	122·4	0·0	122·4	7·6	0·011	0·015	0·160	1·33	Over 2ft
25 „	3 Dec.	128·0	0·0	128·0	7·6	0·020	0·019	0·156	1·54	Over 2ft
17 Dec.	17 Dec.	126·0	0·0	126·0	7·2	0·154	0·024	0·228	1·10	Over 2ft
1904. 19 Jan.	1904. 24 Jan.	119·1	0·0	119·1	8·0	0·007	0·018	0·168	2·00	Over 2ft
16 Feb.	19 Feb.	130·4	1·0	131·4	8·2	0·224	0·025	0·196	1·82	Over 2ft
*†7 Ap.	10 Ap.	114·5	0·0	114·5	7·6	0·003	0·013	0·256	1·33	Over 2ft
	Mean ...	111·9	0·3	112·2	8·3	·098	0·032	0·278	1·73	

* Not included in estimating the Mean.

† After 10 days' rest for repairs of machinery.

CIRCULAR FILTER.—SECTION I.—$\frac{3}{16}''$ TO $\frac{1}{8}''$ PARTICLES.

Date		Parts per 100,000.								Column necessary to obscure test lines (inches).
		Solids.								
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.	
1903. *27 Feb.	1903. 3 Mar.	103·9	0·0	103·9	8·2	0·338	0·087	0·468	3·03	11
12 Mar.	16 Mar.	104·0	0·0	104·0	9·0	0·011	0·017	0·296	2·86	Over 2ft
1 April	3 April	98·3	0·0	98·3	8·2	0·065	0·027	0·280	1·54	Over 2ft
20 „	23 „	126·1	0·0	126·1	9·4	0·194	0·032	0·296	2·00	Over 2ft
28 „	30 „	118·9	0·0	118·9	10·0	0·622	0·053	0·388	1·11	Over 2ft
19 May	21 May	100·3	0·0	100·3	8·0	0·093	0·026	0·272	1·25	Over 2ft
16 June	18 June	104·1	1·3	105·4	8·2	0·032	0·025	0·256	1·43	Over 2ft
15 July	17 July	100·6	0·0	100·6	8·6	0·026	0·021	0·224	1·33	Over 2ft
4 Aug.	6 Aug.	101·5	0·0	101·5	9·4	0·087	0·032	0·296	2·22	Over 2ft
5 Nov.	9 Nov.	122·6	0·0	122·6	7·8	0·010	0·014	0·148	1·43	Over 2ft
25 „	3 Dec.	115·0	0·0	115·0	7·7	0·006	0·016	0·196	1·54	Over 2ft
17 Dec.	17 „	122·1	0·0	122·1	7·4	0·054	0·023	0·200	1·33	Over 2ft
1904. 19 Jan.	1904. 24 Jan.	114·2	0·8	115·0	7·8	0·025	0·018	0·168	1·72	Over 2ft
16 Feb.	19 Feb.	129·5	0·9	130·4	8·2	0·027	0·019	0·132	1·92	Over 2ft
*†7 Ap.	10 Apr.	190·3	0·0	190·3	8·6	0·029	0·018	0·240	6·25	Over 2ft
	Mean ...	112·1	0·2	112·3	8·4	·096	0·025	0·242	1·66	

* Not included in estimating the Mean.

† After 36 days' rest for repairs of machinery.

CIRCULAR FILTER.—SECTION II.—½″ TO ⅛″ PARTICLES.

Date.		Parts per 100,000.								Column necessary to obscure test lines (inches).
		Solids.								
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.	
1903. *27 Feb.	1903. 3 Mar.	100·0	0·3	100·3	8·2	0·560	0·083	0·576	2·50	10
12 Mar.	16 Mar.	99·4	2·0	101·4	9·0	0·014	0·044	0·348	1·54	Over 2ft
1 April	3 April	99·1	0·0	99·1	8·2	0·018	0·032	0·280	1·47	Over 2ft
20 „	23 „	125·8	0·0	125·8	9·2	0·025	0·038	0·296	1·67	Over 2ft
28 „	30 „	118·8	0·5	119·3	9·6	0·101	0·036	0·336	1·54	Over 2ft
19 May	21 May	107·6	0·0	107·6	8·0	0·020	0·030	0·272	1·20	Over 2ft
16 June	18 June	101·5	0·0	101·5	8·2	0·030	0·024	0·296	1·49	Over 2ft
15 July	17 July	100·5	0·0	100·5	8·8	0·022	0·030	0·268	1·25	Over 2ft
4 Aug.	6 Aug.	95·9	12·2	108·1	9·4	0·032	0·037	0·280	1·82	16
5 Nov.	9 Nov.	124·5	0·0	124·5	7·6	0·009	0·021	0·200	1·43	Over 2ft
25 „	3 Dec.	132·0	1·0	133·0	7·6	0·009	0·018	0·208	1·47	Over 2ft
17 Dec.	17 „	121·3	0·0	121·3	7·4	0·035	0·024	0·200	1·67	21
1904. 19 Jan.	1904. 23 Jan.	112·6	1·5	114·1	7·8	0·018	0·019	0·168	1·61	Over 2ft
16 Feb.	19 Feb.	129·6	1·0	130·6	8·2	0·144	0·028	0·220	1·78	16
*†7 Apr.	10 Apr.	182·0	0·0	182·0	8·6	0·004	0·027	0·228	5·55	Over 2ft
	Mean...	112·9	1·4	114·3	8·3	0·036	0·029	0·259	1·53	

* Not included in estimating the Mean.

† After 36 days' rest for repairs of machinery.

CIRCULAR FILTER.—SECTION III.—½″ TO ¼″ PARTICLES.

Date.		Parts per 100,000.									Column necessary to obscure test lines (inches).
		Solids.									
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.		
1903. *27 Feb.	1903. 3 Mar.	102·1	0·0	102·1	8·4	0·493	0·100	0·536	2·70		11
12 Mar.	16 Mar.	100·2	2·2	102·4	8·8	0·015	0·038	0·320	2·00		Over 2ft
1 April	3 April	92·9	0·0	92·9	8·2	0·015	0·031	0·296	1·58		Over 2ft
20 „	23 „	125·9	0·0	125·9	9·6	0·027	0·036	0·296	2·00		Over 2ft
28 „	30 „	120·6	0·0	120·6	9·8	0·043	0·035	0·296	1·43		Over 2ft
19 May	21 May	104·4	0·0	104·4	8·2	0·010	0·027	0·284	1·33		Over 2ft
16 June	18 June	101·4	0·0	101·4	8·0	0·070	0·031	0·280	1·49		Over 2ft
15 July	17 July	102·6	0·0	102·6	8·8	0·012	0·029	0·240	1·25		Over 2ft
4 Aug.	6 Aug.	101·7	5·2	106·9	9·6	0·007	0·033	0·256	2·00		19
5 Nov.	9 Nov.	120·7	0·0	120·7	7·6	0·012	0·021	0·160	1·43		Over 2ft
25 „	3 Dec.	129·8	1·0	130·8	7·6	0·028	0·022	0·208	1·67		Over 2ft
17 Dec.	17 „	120·6	0·0	120·6	7·6	0·043	0·029	0·228	1·61		13
1904. 19 Jan.	1904. 23 Jan.	117·7	0·0	117·7	8·0	0·020	0·032	0·220	1·67		Over 2ft
16 Feb.	19 Feb.	127·8	0·8	128·6	8·0	0·182	0·027	0·196	1·67		14
*†7 Apr.	10 Apr.	190·7	0·7	191·4	8·4	0·007	0·028	0·268	5·0		11
	Mean...	112·8	0·7	113·5	8·4	0·037	0·030	0·252	1·62		

* Not included in estimating the Mean.

† After 36 days' rest for repairs of machinery.

CIRCULAR FILTER.—SECTION IV.—1½″ TO ½″ PARTICLES.

Date.		Parts per 100,000.									Column necessary to obscure test lines (inches.)
		Solids.									
Collection.	Analysis.	In solution.	In suspension.	Total.	Chlorine.	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.		
1903. *27 Feb.	1903. 3 Mar.	99·4	0·0	99·4	8·4	0·732	0·124	0·668	2·0		7·5
12 Mar.	16 Mar.	93·8	5·3	99·1	8·8	0·214	0·057	0·376	1·61		17
1 April	3 April	90·8	0·6	91·4	8·2	0·123	0·039	0·336	1·39		Over 2ft
20 „	23 „	122·5	0·0	122·5	9·6	0·280	0·052	0·348	2·08		Over 2ft
28 „	30 „	119·6	0·0	119·6	9·6	0·446	0·056	0·440	1·25		Over 2ft
19 May	21 May	104·4	1·4	105·8	8·0	0·036	0·035	0·336	1·18		Over 2ft
16 June	18 June	107·6	3·1	110·7	8·0	0·277	0·084	0·508	1·43		Over 2ft
15 July	17 July	101·6	1·3	102·9	8·6	0·042	0·073	0·376	1·43		7
4 Aug.	6 Aug.	103·2	0·0	103·2	9·2	0·011	0·033	0·280	2·00		14
5 Nov.	9 Nov.	123·3	2·8	126·1	7·8	0·010	0·046	0·280	1·61		8
25 Nov.	3 Dec.	128·5	3·7	132·2	7·6	0·008	0·028	0·232	1·43		13
17 „	17 „	130·5	0·3	130·8	7·5	0·012	0·033	0·268	1·82		11
1904. 19 Jan.	1904. 23 Jan.	117·0	0·0	117·0	7·8	0·021	0·025	0·208	1·67		Over 2ft
16 Feb.	19 Feb.	127·4	4·0	131·4	8·0	0·074	0·046	0·300	2·22		7
*†7 Ap.	10 Apr.	176·6	0·6	177·2	8·0	0·004	0·037	0·320	5·55		12
	Mean ...	113·1	1·7	114·8	8·3	0·119	0·046	0·327	1·62		

* Not included in estimating the Mean.

† After 36 days' rest for repairs of machinery.